(12) UK Patent Application (19) GB (11) 2 305 663 (13) A

(43) Date of A Publication 16.04.1997

(21) Application No 9619314.9

(22) Date of Filing 16.09.1996

(30) Priority Data
(31) 95033105 (32) 29.09.1995 (33) KR
9612126 10.06.1996 GB

(51) INT CL^6
C03B 37/027 37/029

(52) UK CL (Edition O)
C1M MBC MBL M400 M401

(56) Documents Cited
GB 2212151 A US 4966615 A

(58) Field of Search
UK CL (Edition O) C1M MBC MBD MBL
INT CL^6 C03B 37/025 37/027 37/029
ONLINE:WPI

P10269 RR

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(54) Optical fibre spinning apparatus and method

(57) An apparatus and method for spinning optical fibres is disclosed. The apparatus includes an optical fibre spinning furnace 10 having an inlet aperture and an outlet aperture. A heating element 24 is provided to heat an optical fibre preform 12 fed in through the inlet aperture, so as to allow a bare optical fibre 40 to be drawn out of the outlet aperture. A flow of inert gas 28 from within the furnace 10 out of the inlet aperture is induced. The inner surface of an inlet sleeve 16, in which the inlet aperture is formed, includes projections and/or indentations 18 which increase its resistance to flow of the outbound inert gas. The method comprises connecting the preform 12 to an auxiliary quartz rod 44 of a smaller diameter; inserting an auxiliary quartz tube 48 over the auxiliary quartz rod 44 of the smaller diameter such that the quartz tube 48 abuts the preform 12; and mounting the preform 12 and quartz rod 44 and tube 48 to a chuck 62 of an optical fibre spinning apparatus.

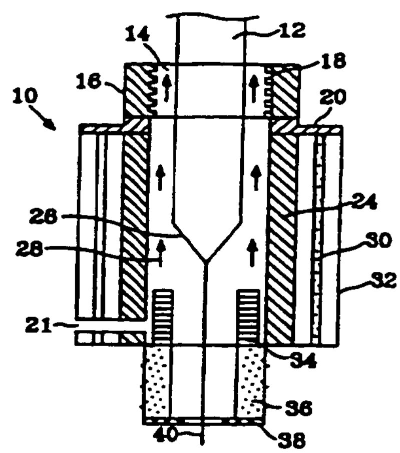

Fig. 4

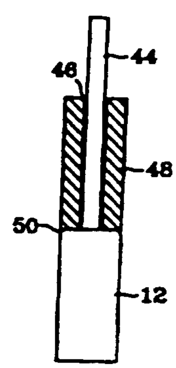

Fig. 6

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At least one drawing riginally filed was informal and the print reproduced here is taken from a lat r filed formal copy.

This print takes account of replacement documents submitted after the date of filing t nable the application to comply with the formal requirements of the Patents Rules 1995

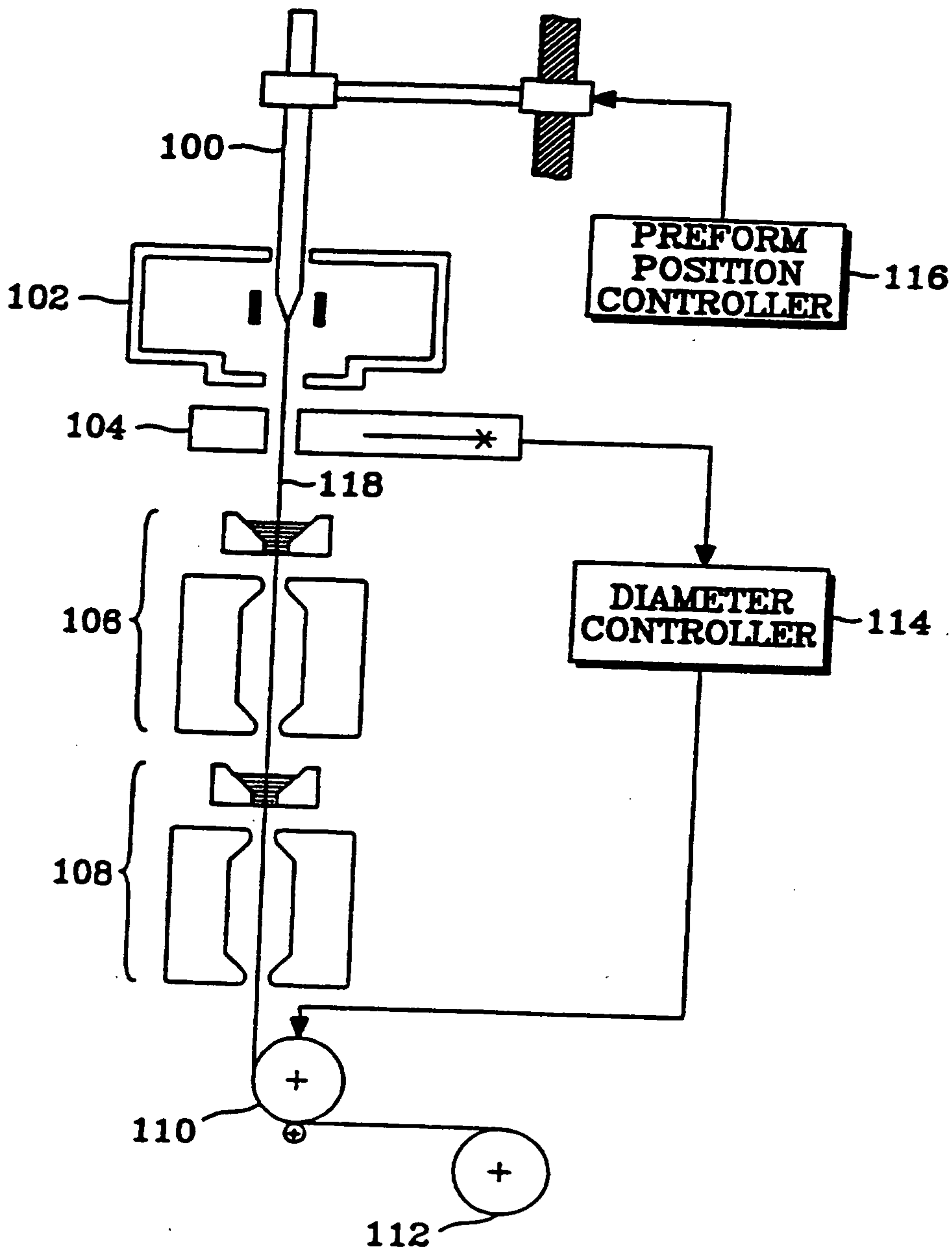
100
102
104
118
106
108
110
112
PREFORM POSITION CONTROLLER
116
DIAMETER CONTROLLER
114

Fig. 1

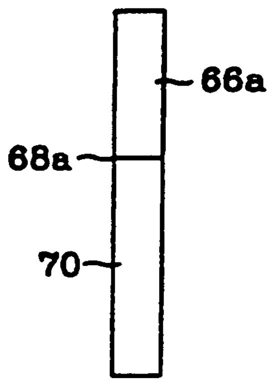

Fig. 2A

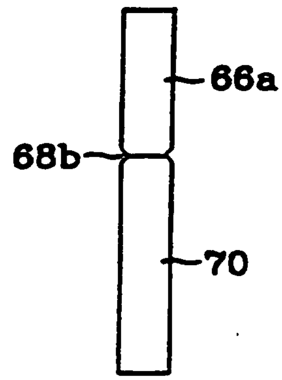

Fig. 2B

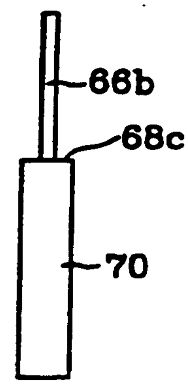

Fig. 2C

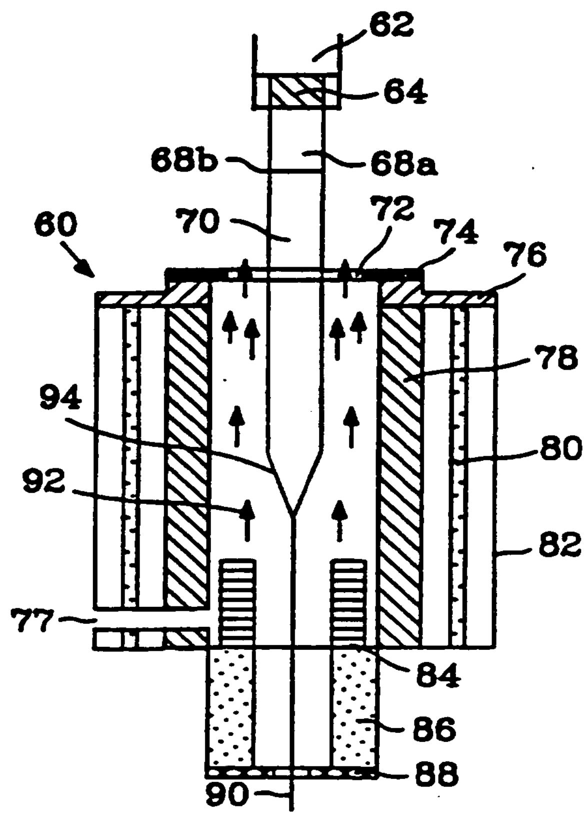

Fig. 3

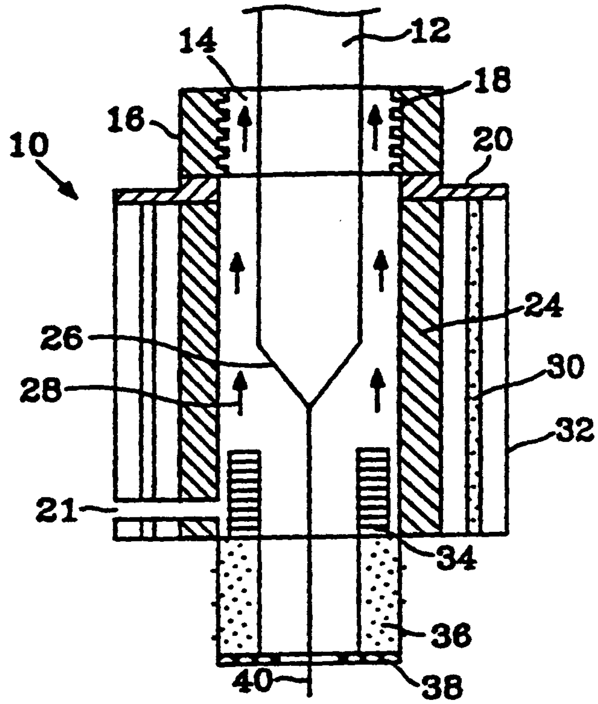

Fig. 4

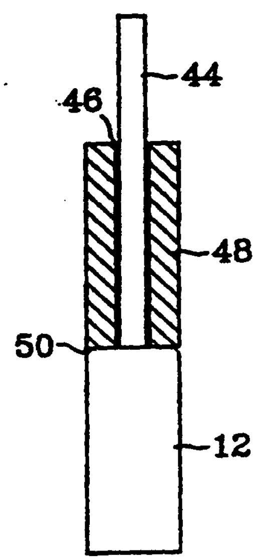

Fig. 6

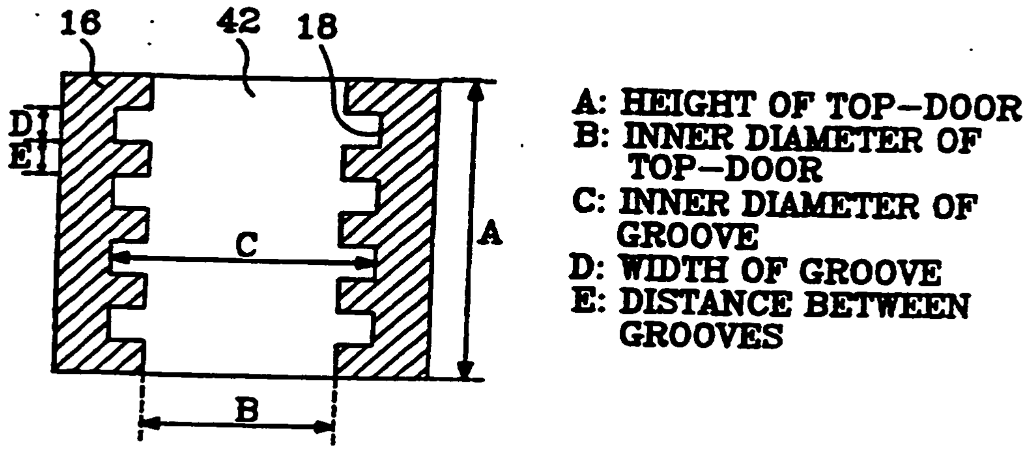

Fig. 5A

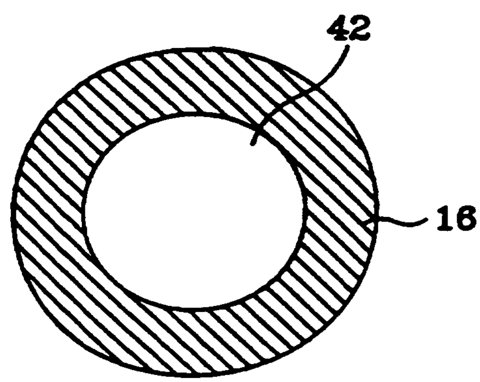

Fig. 5B

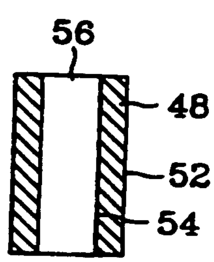

Fig. 7A

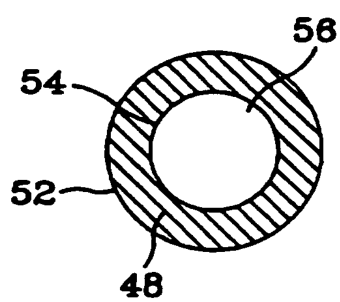

Fig. 7B

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OPTICAL FIBRE SPINNING APPARATUS AND METHOD

This invention relates to the spinning of optical fibres.

FIG. 1 is a general block diagram of an optical fibr spinning apparatus. With reference to FIG.1, the optical fibre spinning process will be described below.

An optical fibre preform 100 is fed slowly into a furnace 102 by the positioning mechanism of a position controller 116. The temperature inside of the furnace is usually thousands of degrees Celsius, and is typically 2100°C - 2300°C. This temperature allows a bare optical fibre 118, from the preform 100, to be pulled out through a tapered end. A capstan 110 provides the pulling force applied to the bare optical fibre 118. An outer diameter detector 104 determines whether the outer diameter of the optical fibre conforms to a predetermined value (typically 125 μm), and provides the result to a diameter controller 114. The diameter controller 114 controls the capstan 110 to maintain the diameter of the bare optical fibre at 125μm. In response to control signals from the diameter controller 114, the capstan 110 rotates, so the pulling tension applied to the optical fibre is adjusted. A primary coating unit 106 and a secondary coating unit 108 coat the descending optical fibre with protective acrylic resin or with protective silicon resin. This operation is performed on relatively cool bare optical fibres. After the above process, the optical fibre pulled out by the pulling tension of the capstan 110 is wound around a spool 112.

FIG. 3 is a sectional view showing the structure of a furnace of a conventional optical fibre spinning apparatus. Inside the furnace 60, which liquefies a preform 70 at high temperature, to spin out an optical fibre 90, a heating element 78 is installed to generate a large amount of heat by electrical resistance. Around the heating element 78, an

insulator 80 is installed to prevent the heat generated by the heating element 78 from transferring to the surroundings. A bottom sleeve 84 made of graphite is installed around the bottom nd in the h ating element 78. At the top of the heating element 78, a gas-diffuser 76 is installed to provide inert gases 92. The gas-diffuser 76 has a thin quartz tube 74 installed at its top end for extraction of inert gases 92. At the bottom of an extended unit 86 installed on the bottom end of the furnace 60, an iris 88 is installed to control the size of the hole through which the optical fibre 90 is drawn.

The above described optical fibre spinning apparatus liquefies the preform 70 at high temperatures usually above 2000°C in the furnace 60 to spin an optical fibre 90 of 125 μm diameter. Generally a graphite resistance furnace 60 is used. However, the graphite resistance furnace 60 generates graphite powder at high temperature, and that could detrimentally affect the mechanical properties of the optical fibre 90.

For this reason, the graphite resistance furnace 60 is equipped with the gas-diffuser 76, 77. The gas diffuser 76, 77 causes inert gas 92, for example Argon or Helium, to flow in the furnace 60, to obtain a uniform quality optical fibre 90. Then the inert gases leave the furnace through a first gap 72 formed between the thin quartz tube 74 and the preform 70 located on the top of the furnace 60. For a typical pressure inside of the furnace 60 exerted by the supplied inert gases 92 and a uniform flow of the inert gases 92, the conditions in the furnace 60 should be steady. To obtain these conditions, a thin quartz tube 74 is installed on the top of the furnace 60, so the preform 70 is inserted through the quartz tube 74 and moves toward the centre of the furnace 60 while the gap between the quartz tube 74 and the preform 70 is maintained at approximately 1 mm.

In the furnac 60 made according to the structure described

so far, conditions within the furnace 60 chang drastically when a preform 70 with slightly varying diamet r pass s through the top r gion of the furnace 60. This is because the inert gases 92 leave the furnace without experiencing any severe restriction, and results in degradation of the quality of the optical fibres 90 produced.

When a preform 70 of a large diameter is used for spinning an optical fibre 90, the preform 70 needs to be mounted in a chuck 62 of an optical fibre spinning apparatus. At least 200 mm of the preform 70 is not used for spinning optical fibres 90 because of the length needed for mounting in the chuck 62 (approximately 50 mm) and the distance between the quartz tube 74 at the top and the preform melting region 26 (approximately 150 mm). Therefore, for full utilization of an expensive preform, the conventional technique attaches an auxiliary quartz rod, as marked by reference numeral 66a and 66b, to one end of a preform as depicted in FIG. 2A, FIG. 2B, and FIG. 2C.

The best connection for the optical fibre spinning operation is achieved when the quartz rod 66a and the preform 70 are of the same diameter and are connected together smoothly as "68a". However, for preforms 70 with large diameters, i.e., 40 mm - 80 mm, it is very hard to connect an auxiliary quartz rod 66a of the same diameter to the preform 70 smoothly like "68a". Even if it is possible to connect, the connection process consumes a lot of time, and the diameter of the connection between the preform 70 and the auxiliary quartz rod easily becomes nonuniform as "68b", and the connection is not made uniformly around the circumference of the preform 70, so that the preform breaks off easily at the connection region when the preform moves. These problems occur more frequently as the diameter of the preform 70 increases.

Another technique based on the prior art uses a quartz rod 66b whose diameter is smaller than that of the preform 70, as is depict d in FIG. 2C. However, the sharp diameter

change, as "68c", causes th pressure and the flow sp ed of th inert gases 92 in the furnace 60 to change as soon as the conn ction enters the furnace 60, so th quality of the optical fibre produced d grades due to th changes in speed and tension of optical fibre spinning and in fibr diameter.

Therefore, to use a large diameter preform 70 with a graphite resistance furnace 60, the connection between the preform and the auxiliary quartz rods 66a and 66b as well as the diameter of the preform 70 along its entire length should be uniform without any abrupt changes. However, since it becomes harder to connect smoothly the preform 70 to the auxiliary quartz rods 66a and 66b as the diameter of the preform 70 increases, the optical fibres 90, spun from the preform 70 within 200 mm from its end, have irregular diameters and this results in optical fibres 90 of inferior quality.

One object of the invention is to minimize the pressure change in the furnace even with a localized diameter variation formed between an optical fibre preform and an auxiliary quartz rod is presented. Another object is to minimize the flow speed changes of the inert gases in a furnace.

A further object of the invention is to connect a preform of optical fibres to an auxiliary quartz rod more easily. Another object of the invention is to improve the quality of an optical fibre.

An optical fibre spinning furnace according to the invention, having an inlet aperture and an outlet aperture, comprises:

a heater adapted to heat an optical fibre preform fed in through the inlet aperture, so as to allow a bare optical fibre to be drawn out of the outlet aperture;

means establishing a flow of inert gas from within the furnace out of the inlet aperture; and

an inlet sleeve in which the inlet aperture is formed, the inner surface of the inlet sleeve including projections and/or indentations which increase its r sistance to flow of the outbound inert gas.

Preferably, at least one groove is formed around the inner circumference of the inlet sleeve. The groove may be formed uniformly around the circumference with regular depth. Preferably, the depth of the groove is at least 0.5 mm, the width of the groove is at least 1 mm and the axial length of the inlet sleeve is at least 10 mm. Where more than one such groove is provided, the distance between the grooves may be at least 1 mm.

Preferably, the axial length and the inner diameter of the inlet sleeve are 450 mm and 53 mm respectively, the depth of each groove is 1.5 mm, the width of each groove is 5 mm, and the distance between grooves is 5 mm.

Alternatively, the inlet sleeve may include at least two such grooves of different depths.

The heater may includes an electrical heating element and may be surrounded by an insulator to prevent heat generated by the heating element from escaping to the surroundings.

A graphite bottom sleeve may be provided surrounded by the heating element and located adjacent to the outlet aperture.

The means for establishing a flow of inert gas may comprise a gas-diffuser located adjacent to the inlet sleeve and the bottom of the heating element.

Preferably, the outlet aperture is defined by an adjustable iris formed in an extended unit.

Preferably, the inner diameter of the inlet sleeve is larger than the diameter of the preform by at least 0.5 mm

but not more than 8 mm.

A method of connecting an optical fibre pr form to an auxiliary quartz rod according to th invention comprises:

connecting the preform to an auxiliary quartz rod of a smaller diameter;

inserting an auxiliary quartz tube over the auxiliary quartz rod of the smaller diameter; and

mounting the preform and quartz rod and tube to a chuck of an optical fibre spinning apparatus.

Preferably, the auxiliary quartz tube is inserted over the auxiliary quartz rod of the smaller diameter such that the quartz tube abuts the preform.

A gap of between 0.5 mm and 4 mm is preferably formed between the inner diameter of the auxiliary quartz tube and the outer diameter of the auxiliary quartz rod.

The outer diameter of the auxiliary quartz tube may be substantially the same as that of the preform. Preferably, the outer diameter of the auxiliary quartz tube differs from that of the preform by at most ± 0.5 mm.

The length of the auxiliary quartz tube may be greater than 50 mm. At least two quartz tubes of less than 50 mm may be used together to form a composite quartz tube having a net length more than 50 mm.

The present invention will now be described by way of example with reference to the accompanying drawings in which:

FIG. 1 is a general block diagram of an optical fibre spinning apparatus;

FIGS. 2A, 2B, and 2C schematically show the structures of a optical fibre preform when the preform is connected to an auxiliary quartz rod in accordance with the prior art;

FIG. 3 is a s ctional view showing the structure of a furnace of a conventional optical fibre spinning apparatus made in accordance with the prior art;

FIG. 4 is a sectional view showing the structure of the furnace of an optical fibre spinning apparatus in accordance with the present invention;

FIGS. 5A and 5B schematically depict sectional views showing the structure of the inlet sleeve installed on th top of the furnace in accordance with the present invention;

FIG. 6 shows the structure of the base of optical fibres when a preform is connected to an auxiliary quartz rod and tube in accordance with the present invention; and

FIGS. 7A and 7B show the structure, employed in the present invention, used to maintain the diameters of an auxiliary quartz tube and a preform of optical fibres at the same diameter.

A preferred embodiment of the present invention will be described in detail with reference to attached figures.

FIG. 4, FIG. 5A, and FIG. 5B are sectional views of the furnace and the inlet sleeve of an optical fibre spinning apparatus according to the present invention, in which a heating element 24 for generating high temperatures by electrical resistance is installed in a furnace 10. The element 24 liquefies a preform 12 to allow an optical fibre 40 to be spun. An insulator 30 is installed around the heating element 24 to prevent the heat generated by the heating element 24 from transferring to the surroundings. A graphite bottom sleeve 34 is installed around the inner bottom of the heating element 24. A gas-diffuser 20 and 21 supplying inert gases 28 is installed on the top and bottom of the heating element 24. An inlet sleeve 16 is installed on the top of the gas-diffuser 20 to be aligned with the

central axis of the heating element 24, to minimize pressure fluctuations within the heating element 24 and the variation in flow rat of the inert gases 28. The inner diamet r of th inlet sleeve 16 is larger than th diam t r of the preform 12 by at least 0.5 mm but not more than 8 mm.

The inlet sleeve 16 is formed with at least one uniform groove 18 around its inner circumference, to prevent a large resistance against the flow of the outbound inert gases 28. The inner diameter B of the groove 18 is larger than the inner diameter C of the inlet sleeve by at l ast 1 mm, (i.e. its depth is at least 0.5mm) the width D of the groove 18 is at least 1 mm, the distance E between grooves is at least 1 mm, and the height A of the inlet sleeve 16 is at least 10 mm. In addition the shape of the inlet sleeve 16 is such that the height A and the inner diameter B of the inlet sleeve 16 are 450 mm and 53 mm respectively, the inner diameter C of the groove 18 is 56 mm, (i.e. its depth s 1.5mm), the width D of the groove 18 is 5 mm, and the distance E between the grooves 18 is 5 mm. At least two grooves 18 may be formed with different diameters.

At the bottom of an extended unit 36 installed beneath th furnace 10, an iris 38, for controlling the size of the hole through which optical fibres are drawn is formed.

In such a furnace the optical fibre preform 12 is inserted into the furnace 10 through the centre of the inlet sleeve 16, and the inert gases 28 leave the furnace 10 through a first gap 14 between the preform 12 and the sleeve 16. While the inert gases 28 leave the furnace, the effect on the conditions inside of the furnace 10 is relatively small because the inlet sleeve 16 of the furnace 10 is formed with a height A greater than that of the furnace 60 of the prior art and the inner surface of the sleeve 16 has many grooves 18 of different diameters, thus offering a large resistance against th inert gases 28 when they leave the furnace 10 through the first gap 14.

Therefore, this furnace can minimize the degradation of the quality of optical fibres which stems from the variation of the conditions inside of the furnac even when a pr form is connected to an auxiliary quartz rod so as to have som variation in diameter. Also, the furnace has an inlet sleeve which minimizes fluctuations in flow speed of the inert gases and the pressure inside the furnace even when the preform is connected to an auxiliary quartz rod with some localized diameter variations.

FIGS. 6, 7A and 7B are sectional views showing a method and an apparatus for connecting an optical fibre preform to an auxiliary quartz rod and tube.

The method of connecting the preform 12 to an auxiliary quartz rod 44 will be described below with reference to FIG. 6.

The first step is to connect the preform to an auxiliary quartz rod 44 of a smaller diameter than the diameter of the preform 12 which is performed with ease because of the smaller diameter of the quartz rod 44.

The second step is that an auxiliary quartz tube 48 made of the same material as the preform 12 is positioned around the quartz rod of smaller diameter and then rests on top of the preform 12, to prevent the problems in spinning the optical fibre 40 due to large variations in diameter between the auxiliary quartz rod 44 and the preform 12 of optical fibres. The outer diameter of the quartz tube 48 is the same as that of the preform 12. The inner diameter of the quartz tube structure is such that a second gap 46 of a predetermined size is formed when the quartz tube 48 encloses the auxiliary quartz rod 44. The second gap is larger than 0.5 mm and smaller than 4 mm. The outer diameter of the quartz tube 48 may differ from the outer diameter of the preform by ± 0.5 mm. The length of the quartz tube 48 is more than 50 mm, or more than two quartz tubes of shorter length may be used together to form a net

length of more than 50 mm.

The third step is mounting the preform 12 connected to the quartz rod 44 and th quartz tub 48 to a chuck 62 of an optical fibre spinning apparatus, and spinning the optical fibres 40.

When a preform 12 is made according to the above, th connection between the quartz tube 48 and the preform 12 is somewhat depressed inward. This is because when a preform 12 and an auxiliary quartz rod 44 are heated before their connection, the flame of the burner rounds the sharp edges of the preform. This slight depression causes the conditions inside of a graphite resistance furnace 60 according to the prior art to change as soon as the gap starts passing the furnace 60. But if an inlet sleeve 16 in a furnace according to the present invention is used, then the gap formed at the connection 50 between the preform 12 and an auxiliary quartz rod 44 does not have any effect on the conditions inside of the furnace 10.

Accordingly, the method described so far has the following advantages. It is easy to use because the quartz tube is easily attached to and removed from an optical fibre preform and an auxiliary quartz rod. It reduces production cost because of the increased possibility of recycling. The connection is made very simply when the large diameter preform is connected to an auxiliary quartz rod.

CLAIMS:

1. An optical fibre spinning furnace having an inlet aperture and an outlet aperture and comprising:

a heater adapted to heat an optical fibre preform fed in through the inlet aperture, so as to allow a bare optical fibre to be drawn out of the outlet aperture;

means establishing a flow of inert gas from within the furnace out of the inlet aperture; and

an inlet sleeve in which the inlet aperture is formed, the inner surface of the inlet sleeve including projections and/or indentations which increase its resistance to flow of the outbound inert gas.

2. A furnace according to claim 1 in which at least one groove is formed around the inner circumference of the inlet sleeve.

3. A furnace according to claim 1 in which the groove is formed uniformly around the circumference with regular depth.

4. A furnace according to claim 2 or claim 3 in which the depth of the groove is at least 0.5 mm, the width of the groove is at least 1 mm and the axial length of the inlet sleeve is at least 10 mm.

5. A furnace according to claim any one of claims 2-4 in which more than one such groove is provided and the distance between the grooves is at least 1 mm.

6. A furnace according to claim 5 in which the axial length and the inner diameter of the inlet sleeve are 450 mm and 53 mm respectively, the depth of each groove is 1.5 mm, the width of each groove is 5 mm, and the distance between grooves is 5 mm.

7. A furnace according to any one of claims 2-4 in which the inlet sleeve includes at least two such grooves of

different depths.

8. A furnace according to any preceding claim in which the heater includes an electrical h ating element.

9. A furnace according to claim 8 further including an insulator surrounding the heating element to prevent heat generated by the heating element from escaping to the surroundings.

10. A furnace according to claim 8 or claim 9 further including a graphite bottom sleeve surrounded by the heating element and located adjacent to the outlet aperture.

11. A furnace according to any preceding claim in which the means for establishing a flow of inert gas comprises a gas-diffuser located adjacent to the inlet sleeve and the bottom of the heating element.

12. A furnace according to any preceding claim in which the outlet aperture is defined by an adjustable iris formed in an extended unit.

13. A furnace according to any preceding claim in combination with an optical fibre preform in which th inner diameter of the inlet sleeve is larger than the diameter of the preform by at least 0.5 mm but not more than 8 mm.

14. A method of connecting an optical fibre preform to an auxiliary quartz rod comprising:

connecting the preform to an auxiliary quartz rod of a smaller diameter;

inserting an auxiliary quartz tube over the auxiliary quartz rod of the smaller diameter; and

mounting the preform and quartz rod and tube to a chuck of an optical fibre spinning apparatus.

15. A method according to claim 14 in which th auxiliary quartz tube is inserted over the auxiliary quartz rod of the smaller diameter such that the quartz tube abuts the preform.

16. A method according to claim 14 or claim 15 in which a gap of between 0.5 mm and 4 mm is formed between the inner diameter of the auxiliary quartz tube and the outer diameter of the auxiliary quartz rod.

17. A method according to any one of claims 14-16 in which the outer diameter of the auxiliary quartz tube is substantially the same as that of the preform.

18. A method according to claim 17 in which the outer diameter of the auxiliary quartz tube differs from that of the preform by at most ± 0.5 mm.

19. A method according to any one of claims 14-18 in which the length of the auxiliary quartz tube is greater than 50 mm.

20. A method according to claim 19 in which at least two quartz tubes of less than 50 mm are used together to form a composite quartz tube having a net length more than 50 mm.

21. An optical fibre spinning furnace substantially as described herein with reference to FIGs. 4-5B of the accompanying drawings.

22. A method of connecting an optical fibre preform to an auxiliary quartz rod, substantially as described herein with reference to FIGs. 6 et seq. of the accompanying drawings.

The Patent Office

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Applicati n No: GB 9619314.9
Claims searched: 1-13

Examiner: C.A.Clarke
Date of search: 4 December 1996

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): C1M (MBL,MBC,MBD)

Int Cl (Ed.6): C03B 37/025,027,029

Other: ONLINE: WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB 2212151 A	STC see figs and p4	1 at least
X	US 4966615	OY NOKIA see whole document	1 at least

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& Member of the same patent family
A Document indicating technological background and/or state of the art.
P Document published on or after the declared priority date but before the filing date of this invention.
E Patent document published on or after, but with priority date earlier than, the filing date of this application.